DOCUMENT RESUME

ED 375 855 IR 055 259

AUTHOR Bell, Benjamin
TITLE The Effects of Task, Database, and Guidance on Interaction in a Goal-Based Scenario.
PUB DATE Apr 94
NOTE 14p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 4-8, 1994).
PUB TYPE Reports - Descriptive (141) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Simulation; *Hypermedia; *Instructional Design; Instructional Effectiveness; Multimedia Instruction; Museums; *Role Playing; Science Instruction; *Sickle Cell Anemia
IDENTIFIERS Goal Based Education; Museum of Science and Industry IL; *Sickle Cell Counselor (Computer Simulation)

ABSTRACT

This paper describes the "Sickle Cell Counselor" (SCC), a goal based scenario on permanent display at the Museum of Science and Industry in Chicago. SCC is an exploratory hypermedia simulation program which provides users with a basic understanding of Sickle Cell Anemia. The user of the program plays the role of a genetic counselor, and, while playing this role, can do laboratory tests, calculate risks, ask experts for information, and advise clients about the results. The paper begins with a brief description of the SCC which emphasizes the design features most relevant to the patterns of interaction that emerged. These include the design of the task presented to the user, the organization of the database, and guidance given to the user by the system. Three evaluations of SCC which were conducted with museum users in order to better understand how they interacted with the program, are also presented. These studies examined patterns of usage, the cognitive gain of the program, and the effects the counseling task had on learning. Discussions of how particular features of the program affected the interactions of the users and their implications for the design of computer-based learning environments conclude the paper. (Contains 17 references.) (JLB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☐ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

ED 375 855

The effects of task, database, and guidance on interaction in a Goal-Based Scenario†

Benjamin Bell
The Institute for the Learning Sciences
Northwestern University
Evanston, IL 60201
bell@ils.nwu.edu

Introduction

Computer-based learning environments provide an opportunity to situate instruction within engaging and authentic contexts. There are a number of advantages to this approach: such contexts can support failure-driven learning (Schank, 1982); they can display the range of phenomena a student might encounter later (Schank, 1991); skills and knowledge presented in-context are more easily learned (Brown, et al., 1989); their utility is readily conveyed by the context (Bransford, et al., 1990). Results from studies of anchored instruction, for example, suggest the benefits provided by the context with regard to learning how and when to apply new knowledge, in addition to acquiring the new knowledge itself (*e.g.*, CTGV, 1992; Goldman, Vye, Williams, & Rewey, 1992).

One specialization of anchored instruction introduces the requirement that the student become engaged in a role-playing situation, actively pursuing task objectives on his or her own behalf, as an agent in the simulated environment. This is the approach adopted by *Goal-Based Scenarios* (Schank, Fano, Bell, & Jona, in press). *Sickle Cell Counselor* is a Goal-Based Scenario (GBS) we designed, which is now on permanent display at the Museum of Science and Industry in Chicago. Using this hypermedia simulation program, visitors learn about Sickle Cell Disease by helping couples seeking advice about the potential risks of Sickle Cell.

† Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA, April, 1994.

IR055059

BEST COPY AVAILABLE

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Benjamin L. Bell
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

In this paper, I briefly describe Sickle Cell Counselor, emphasizing the design features most relevant to the patterns of interaction which emerged. I then summarize three evaluations of SCC we conducted in order to better understand how users interact with the program, and discuss how particular features of the program affected those interactions. I conclude by examining how these result might be generalizable to a broader class of interactive learning environments.

The Design of Sickle Cell Counselor

A brief description of Sickle Cell Counselor

SICKLE CELL COUNSELOR (Bell, Bareiss, & Beckwith, in press) is an exploratory hypermedia system which provides users with a basic understanding of Sickle Cell Disease. The user of the program plays the role of a genetic counselor, assisting clients who have expressed an urgent desire to learn more about Sickle Cell. The four main activities a user can do while playing this role are doing lab tests, calculating risks, asking experts for information, and advising the clients about the results.

The program provides access to a simulated blood lab, giving the user a chance to draw blood samples from each client, view them under the microscope, and perform lab tests in order to determine the clients' hemoglobin genotypes. To calculate the clients' risks the user can access a Punnett Square, a simple visualization tool which also acts as a "genetic spreadsheet". To make domain knowledge available to the user, an experts screen is available which provides access to a physician, a geneticist, a lab technician, and a guide. Finally, the user can advise the clients by selecting one of three types of advice from a menu. The clients' reaction depends on what the user has explored, and on the type of advice the user gives, *e.g.*, "It's too risky for you to have kids," or "You have enough information - do as you think is best."

Summary of the relevant design issues

Several of the design issues encountered in creating SCC are of particular relevance to how users later employed the system as a learning device. Below I discuss the design of the task presented to the user, the organization of the database, and guidance given the user by the system.

Task

An early design step involved establishing the instructional goals of the program, in terms of a set of target skills and knowledge. A challenging aspect of this step is selecting an interesting goal for the student to pursue, such that the means for pursuing it rely on the student mastering (at some level of competence) the target skills and knowledge.

The instructional goals of Sickle Cell Counselor were expressed as a small set of concepts a visitor would learn in a typical interaction with the program, *e.g.*, recessive patterns of inheritance. To invent a goal for the user to pursue, we posed the question, "What motivating goal requires knowledge of the target concepts to achieve?". Advising couples about the risks of Sickle Cell Disease was selected because doing it requires knowledge of basic genetics and of Sickle Cell, and because helping people is an interesting goal.

What is relevant here is the relationship between the target concepts and the task goal. From the point of view of the user, the program is about counseling clients. From the perspective of the designer, though, the program is about learning diagnosis, transmission patterns, and effects of Sickle Cell Disease. Put another way, Sickle Cell Counselor is not meant to teach genetic counseling. The task is simply an artifice, employed to situate the pedagogical objectives of the program within an engaging context.

A requirement of the task, though, is that it organize the target knowledge so that users recognize the relevance of the information they're acquiring to the task, and are able to assess the state of their own knowledge (Bransford et al., 1990). In SCC, the link between the information being explored and the task at hand is transparent, since the user's objective is to seek out and

provide the clients with the information they need. In other words, the knowledge users gather as counselors is the same as the knowledge that we want them to acquire as learners.

Organization of the Database

One way to support a user in pursuing the task goals is to make experts available of whom the user could ask appropriate questions when needed. In SCC, expert knowledge is available to the user in a database of video clips which the user can explore by posing questions to various experts.

The brief video clips in the database answer questions which our task analysis suggested were related to the user's goal. These clips were organized using the ASK methodology (Ferguson et al., 1992) to index contextually relevant material. The ASK methodology provides a way of building hypermedia systems, based on the metaphor of conversation with an expert rather than on the more common metaphor of a well-indexed book. When interacting with an ASK system, a user sees/hears/reads a piece of information causing questions to arise in his or her mind. The user may then ask any of the logical follow-up questions for which the system has a good answer.

Asking questions of experts serves the dual objectives of advancing the task goals and supporting the program's instructional goals. The way in which the user incrementally gathers information is consistent with the task, since getting expert advice in order to help the clients is part of what the user-as-counselor does. Applying what the experts say to constructing an account of Sickle Cell is also a central part of the exploration process in which the user is engaged while determining the clients' risks and how to advise them.

Guidance

An additional design issue arises from the need to support the user in pursuing the task goals. An exploratory environment can provide rich resources but fail to sufficiently scaffold

exploration (Hawkins, Mawby, & Ghitman, 1987; Pea, 1987). Task guidance in SCC includes both explicit and implicit support.

Explicit Task Guidance

SCC provides explicit task guidance in the form of questions the user may ask the Guide (who is always available), such as "what can I do now?" or "why did the clients say that?" This form of coaching (Collins et al., 1989) supplies needed help but keeps the user in control and avoids having the program guess when (because the user asks for help) and why (because multiple questions are available to ask the guide) the user needs help.

A second sort of task guidance supports the user in doing blood tests and calculating risks. In the blood lab, for example, the task of electrophoresis is supported by simplifying the procedure, offering a key for reading the results, and making the Lab Technician available to answer questions about the test and its interpretation. This scaffolding (Collins et al., 1989) allows the user to conduct a conclusive laboratory test without having to acquire the (considerable) background knowledge of electrophoresis principles and practices. Similar scaffolding is evident in using the microscope and in calculating genetic outcomes with the Punnett Square.

Implicit Task Guidance

Additional task guidance is embedded within the model which directs how the clients behave. When the user decides to advise the clients, their response contains clues to help the user infer how to best satisfy the counseling objectives. For example, an angry client who demands "What's so risky about carrying the Sickle Cell Trait?" is not only reacting to a user's advice that the risks are too great, but is also providing implicit guidance for the user to explore the medical implications of Trait. Seen in this way, the clients not only behave as agents in the scenario, they also embody an implicit representation of the user's task. Using the clients as a device for guiding the user's exploration can be seen as yet another way of scaffolding the task.

Evaluations of Sickle Cell Counselor

SCC was evaluated in three studies: an in-museum study to measure usage patterns, a cognitive gain study to assess learning of factual material pertaining to Sickle Cell, and a controlled study of the effects the counseling task has on learning.

Patterns of Usage

An important question to answer about SCC is whether users are able to recognize, and willing to act out, the role established by the program. A study conducted in the Museum of Science and Industry addressed this issue through interviews of ninety-seven users (Bell, Bareiss, & Beckwith, 1993) . The interviews reveal that ninety-six of them (99%) knew they were acting as genetic counselors. Analysis of 1,416 transcripts collected automatically by the program indicate an average usage time of over seven minutes, which is far in excess of the one and a half minutes typically spent at an exhibit at MSI. This figure provides an indication that visitors were engaged by the program. What users did during this period is also of interest. Approximately half of the museum users visited the experts screen. We also noted from the transcripts that there was a bimodal distribution in usage times, with the higher mean correlated with more time spent exploring the expert screen. Finally, demographic analysis rules out the possibility that the usage times observed are attributable to a user population which is overwhelmingly at risk for Sickle Cell Disease or overwhelmingly adult. The longer than expected period of use can be explained only by the motivation and interest provided by the system itself.

Cognitive Gain

A second study measured the acquisition of factual information about Sickle Cell by users of the program (Bell, Bareiss, & Beckwith, 1993). In this study, identical pre-and post-tests were administered to ten subjects which included questions about various aspects of Sickle Cell

Disease, for example "What is Sickle Cell Disease", and "How is Sickle Cell Disease transmitted". A significant difference we observed was the lower incidence of "don't know" answers in posttest results as compared with the pretest results. Another significant result was the increase in the average number of appropriate concepts in the answers in the posttests. Although this study was inconclusive, it did demonstrate unequivocally that basic concepts about Sickle Cell can be learned by using the program.

Learning Metaknowledge

A third study addressed the issues of whether people learn from the program and how it compares to other media (Bell, Bareiss, & Beckwith, in press). In this study, a group of subjects using Sickle Cell Counselor were compared with a group of subjects who read a pamphlet about Sickle Cell. We created the pamphlet by collecting the dialogs from the video clips most commonly seen in the program, and the computer graphics from the lab activities, and editing them into a coherent text. A third group of subjects served as a control group. There were nine subjects in each condition. Assessment was done via structured interviews in which subjects were asked to play the role of a prospective client. We chose the role playing format rather than simple factual recall (as in the previous study) because one purpose of the anchoring task in SCC is to promote appropriate recall in realistic settings.

Previous research has found fewer irrelevant responses on some tasks by anchored (but not unanchored) subjects, suggesting that "irrelevance is a reasonable index of the subjects' ability to determine what is important. High rates of irrelevant statements would suggest a poor understanding" (Bareiss & Beckwith, 1993). We expected that subjects would learn about Sickle Cell Disease from either the system or the pamphlet and, thus, would differ from the control group in the assessment. However, this was not the case. Although the subjects who used Sickle Cell Counselor did generate significantly more correct responses than the control group, the pamphlet group subjects did not differ significantly from the control group subjects on any of the measures.

BEST COPY AVAILABLE

With respect to our two experimental groups, we were most interested in seeing whether in the role playing there were differences between the groups in learning the conditions of applicability of the knowledge, since that is expected to be a primary effect of an anchoring task. As we had expected, the subjects who used Sickle Cell Counselor had significantly fewer irrelevant responses on the post test. It is this finding, regarding learning the conditions under which new knowledge is appropriate (*i.e.* knowledge about knowledge, or metaknowledge), which most directly addresses the effect of situating exploration within a task context.

Discussion

The three studies summarized above indicate that Sickle Cell Counselor was usable and engaging; that it taught basic factual knowledge about Sickle Cell; and that its users acquired a better understanding of the utility of the new knowledge than did those given similar material in the absence of the task context. But which design attributes of SCC contribute to these evaluation data? Specifically, what do these findings suggest about the Task, Organization of the Database, and Guidance?

Task

With respect to the task, the usage-pattern findings suggest that actively engaging the user in a compelling role is an effective means for motivating exploration. Furthermore, carefully designing the task to mirror the subject matter makes such exploration more enriching. Finally, embedding the target concepts within an authentic context promotes learning of, not only the target concepts themselves, but also of the conditions of applicability of those concepts. Findings from the controlled study suggest in addition that the task helped to promote transfer of knowledge from the counseling context in the program to the context of being a client in the posttest interview. Subjects using the system were better able to bring the appropriate knowledge to bear in projecting what their actions would be in this different context, compared to subjects reading the pamphlet.

Organization of the Database

The organization of the database serves a supporting function by providing access to expert knowledge in a way which is both intuitive and consistent with the task. The usage pattern study suggests, based on the bimodal distribution of mean usage times, that there are two kinds of users: goal-oriented and knowledge-oriented (Cleave, Edelson, & Beckwith, 1993; Mcgee & Beckwith, 1993). What can be inferred from this is that users not only recognized the experts screen as a means for accessing the database, they were able to make use of it for that purpose. Our analysis also suggests that the program could be improved by more strongly encouraging users to explore the breadth of information available from the experts. Observations from the usage pattern study suggest that the experts screen was underutilized (that is, information appropriate to the task which was available by asking experts was not explored). What may be needed is to integrate more basic information directly into the investigation activities (such as the Blood Lab), which were much more widely used in general.

An additional effect of the organization of the database was seen in the controlled study: users of the system generated significantly more correct responses than the control group, whereas the group reading the pamphlet did not differ significantly from the control group on any of the measures. If we regard the pamphlet as presenting a linearly-organized database, we can interpret this result as support for organizing a database nonlinearly, in this case, as a hypermedia system for supporting conversational exploration, that is, an ASK system.

Guidance

Although we did not directly evaluate the design of the guidance component, a few observations should be noted. The explicit task guidance can be examined from the standpoint of how extensively users interacted with the Guide; transcripts generated by the system reveal that users asked, on average, eight questions of the Guide (and two questions of the Lab Tech, who also provides primarily task guidance).

To examine the implicit task guidance, we need to look at users who triggered reactions from the clients. Among the approximately forty-eight percent of museum users who dispensed erroneous advice, more than half returned to the system and eventually concluded the session successfully. We cannot directly attribute this to the guidance implicit in the clients' behavior, but these observations are indicative that users responded to the clients by continuing to explore the system.

We did not attempt to compare our approach with alternatives, but our evaluations do offer an indication that the program's guidance component was sufficient to support the user's task objectives. Our aim was to provide essential help in a way that was consistent with the scenario; embedding guidance within the Guide, Lab Tech, and client couples allowed users to remain within the counseling context, even when they required assistance.

Implications for the design of computer-based learning environments

The previous discussion identified three major design components of Sickle Cell Counselor, and how each affected the learning resulting from interaction with the system. In this section, I consider what implications these components have for designing computer-based leaning environments.

Task

Our results suggest that teaching within an authentic task context does indeed promote learning the conditions under which target concepts are relevant. This conclusion arises from the greater selectivity of knowledge shown by the subjects who used the system as compared with that shown by the subjects reading the pamphlet. Advising the clients seems therefore to have provided a framework for users to usefully encode new knowledge. Since teaching the applicability of knowledge is a strong motivation for computer-based learning environments, this result suggests that instructional activities in such systems should be embedded within a realistic task.

Another result from the evaluation data is that the task helped to promote transfer of knowledge from the counseling context in the program to the context of being a client in the posttest interview. Subjects using the system were better able to bring the appropriate knowledge to bear in projecting what their actions would be in this different context, compared to subjects reading the pamphlet. An observation from this result is that situating instruction in different contexts provides an opportunity to promote transfer. This suggests that one objective of computer-based learning environments should be to make multiple contexts available for learning any given course of instruction.

Organization of the database

The database of video clips in Sickle Cell Counselor served a twin purpose. By presenting the user with domain experts who could be consulted, it added another dimension to the task activities. At the same time, it made a rich source of information available to the user in an intuitive, conversational way. Results from our evaluations, while not definitive regarding the role played by this browsing network, do offer suggestive evidence that "conversing" with experts helps engage learners' interests, and supplies contextually appropriate domain knowledge. This approach can be generalized to, and is appropriate for, any computer-based learning environment which possesses a library of specific information, and which places the learner in a role from which he or she could interact with knowledgeable agents.

Guidance

Sickle Cell Counselor assists a user by providing implicit and explicit task guidance. Results from our evaluations suggest that user-initiated task guidance is an effective means for supporting users, helping them manage the demands of the task while permitting the interaction to remain under the users' control. This conclusion echoes previous work on *Button Theory* (Jona, Bell, & Birnbaum, 1991), which captured a range of utterances a user typically employs to express a need for guidance, representing each one as an icon on a graphical button pad. We

believe that by adapting the button pad metaphor to one of asking questions of a more experienced colleague, task help becomes better integrated with the task context itself.

Implicit task guidance, too, may be generalized as a design principle. In our approach, the reaction of the clients to a user's advice is informative, not only with respect to whether the advice was "good" or "bad", but also with respect to how the user should proceed. As a general approach, then, the behavior of agents in a simulation should be governed in part by a task model, so that they are not only reactive, but serve also as an additional source of task guidance.

Conclusion

I have described Sickle Cell Counselor, a simulation-based instructional learning environment, with respect to three design criteria: the task, the database organization, and the guidance. Evaluations performed of this system highlight patterns of interaction which are attributable, to varying degrees, to the choices made for these criteria. I have synthesized from these findings some implications for computer-based learning environments in general.

More work is needed in the area of designing supports for the learner. Our evaluations shed much light on the design of the task, but less on the design of other program elements, such as guidance, which support the learner in carrying out the task. We are currently implementing a tool to help a designer create, not only a meaningful task for the user, but the guidance, expert questions, and navigation necessary to completely instantiate the task in an instructionally-effective learning environment.

References

Bareiss, R., and Beckwith, R. (1993) Advise the President: A Hypermedia Approach to Teaching Contemporary American History to High School Students. Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA.

Bell, B.L., Bareiss, R., and Beckwith, R. (1993). The role of anchored instruction in the design of a hypermedia science museum exhibit. Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA.

Bell, B.L., Bareiss, R., and Beckwith, R. (in press). Sickle Cell Counselor: A prototype Goal-Based Scenario for instruction in a museum environment. *Journal of the Learning Sciences, 3*(4), forthcoming

Bransford, J., Sherwood, R., Kinzer, C., Hasselbring, T., & Williams, S. (1990). Anchored instruction: Why we need it and how technology can help. In D. Nix & R. Spiro (Eds.), Cognition, education, and multimedia: Exploring ideas in high technology (pp. 115-141). Hillsdale, NJ: Lawrence Erlbaum.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-41.

Cognition and Technology Group at Vanderbilt (CTGV). (1992). The Jasper Series as an example of anchored instruction. *Educational Psychologist, 27*, 291—315.

Cleave, J.B., Edelson, D., and Beckwith, R. (1993). A Matter of Style: An Analysis of Student Interaction with a Computer Based Learning Environment. Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA.

Collins, A., Brown, J.S., and Newman, S. (1989). Cognitive Apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L.B. Resnick (Ed.), *Knowing, Learning, and Instruction: essays in honor of Robert Glaser*. Lawrence Erlbaum: Hillsdale, N.J.

Goldman, S.R., Vye, N.J., Williams, S.M., and Rewey, K. (1992). *Planning net representations and analyses of complex problem solving*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Ferguson, W., Bareiss, R., Birnbaum, L., and Osgood, R. (1992). ASK systems: an approach to the realization of story-based teachers. *Journal of the Learning Sciences, 2*(1), 95-134.

Hawkins, J., Mawby, R., and Ghitman, J.M. (1987). Practices of novices and experts in critical inquiry. In R.D. Pea and K. Sheingold (Eds.), *Mirrors of Minds: Patterns of Experience in Educational Computing*. Norwood, NJ: Ablex.

Jona, M.K., Bell, B.L., and Birnbaum, L. (1991). Button theory: A taxonomy of student-teacher communication for interface design in computer-based learning environments. In *Proceedings of the Thirteenth Conference of the Cognitive Science Society*, Chicago, IL, 1991.

McGee, S., and Beckwith, R. (1993). The value of traveling aimlessly. Paper presented at the annual meeting of the American Educational Research Association, Atlanta, GA.

Pea, R.D. (1987). Human-machine symbiosis: Exploring hypermedia as new cognitive and cultural technologies. Paper presented at the International Symposium on Computers, Cognition, and Epistemology, Sandbjerg Castle, Denmark.

Schank, R. C. (1982). Dynamic Memory: A Theory of Reminding and Learning in Computers and People. Cambridge: Cambridge University Press.

Schank, R.C. (1991). Case-based teaching: Four experiences in educational software design. Technical Report No. 7, The Institute for the Learning Sciences, Evanston, IL.

Schank, R.C., Fano, A., Bell, B.L. , and Jona, M.Y. (in press). The Design of Goal Based Scenarios. *The Journal of the Learning Sciences, 3*(4), forthcoming.